path is energized by high frequency voltage and wherein the rate of movement is measured by the capacitance between the first and second conductive paths.

26. (Amended) The method of claim 24, wherein at least one conductive path is energized by direct current and wherein the rate of movement is measured by rate of relaxation of the resilient member.

Remarks.

The above amendments to the specification aim at avoiding possible ambiguities, and the amendments to the claims are based on the Examiner's suggestions set forth in the Official Action of 25 September 2002. The amendments do not add new matter to Applicants' original disclosure and are believed to put the application into a condition suitable for allowance.

Applicants are submitting herewith a letter addressed to the Official Draftsman with red-inked proposals for changing Fig. 1 of the drawings as suggested by the Examiner. The rejection under point 3 of the Official Action has been rendered moot by incorporating reference numeral --11-- in line 3, page 12, after "layer (first occurrence).

A copy of the amended claims with brackets and underlines is tendered under cover hereof.

It is urged that the application as hereby amended is in condition for allowance which is earnestly solicited.

Respectfully submitted,

Karl Hormann
Registration No.: 26,470

Area Code 617.491.8867
Enclosures

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

Application No.: 09/865,338
Filed 28 May 2001
By: Ehwald et al.
For: Method and Apparatus
for Measuring Viscosity

Examiner: Larkin, Daniel Sean
Group Art Unit: 2856

Amended Paragraphs of Specification

The paragraph beginning at line 1 of page 5 is to be replaced by the following rewritten paragraph:

--A specific object of the invention is to provide for a method and an apparatus for [measuring, by] affinity[, the viscosity of] viscometry using very small quantities of highly viscous fluids and for deriving signals thereof.--

The paragraph beginning at line 9 of page 5 is to be replaced by the following rewritten paragraph:

--In the accomplishment of these and other objects, the invention[, in general,] provides a sensor for [affinity] viscosity measurements in [of] small fluid volumes without fluid consumption, and for [the fabrication of] methods of fabricating a [viscometric] miniaturized sensor suitable for carrying out such measurements, including affinity viscometry.--

The paragraph beginning at line 4 of page 8 is to be replaced by the following rewritten paragraph:

--In an alternate embodiment of the invention, at least one movable cantilevered conductor is positioned in the effective field of a permanent magnet such that the flux lines thereof extend substantially normal to the main directional

movement of the conductor.--

Line 4 of page 9 is to be rewritten as follows:

--Fig. 2 is a sectional view on an enlarged scale along line II - II of Fig. 1.--

The paragraph beginning at line 13 of page 11 is to be replaced by the following rewritten paragraph:

--As regards the fabrication of the apparatus described, the structuring of the measuring zone and the movable loop 3 is significant. In accordance with the invention, the movable loop 3 is fabricated only after formation of all active and passive components of the integrated circuit of the viscosity sensor has been completed, by applying an additional photo lithographically structured lacquer mask prior to opening the passivation windows and separation of the sensor chips produced on a semiconductor substrate (wafer). The mask serves, [to undercut] by a localized isotropic insulator etching process, to undercut and completely separate from the insulating support, the uppermost portion of the conductor plane which in the completed sensor constitutes the resiliently movable loop 3.--

The paragraph beginning at line 1 of page 12 is to be replaced by the following rewritten paragraph:

--This may be accomplished by the upper partial layer 10 of the intermediate insulator consisting of silicon dioxide or silicate glass and a lower partial layer 11 consisting of Si_3N_4. The windows in the passivation layer 12 which also consists of Si_3N_4, which have been structured with the above-mentioned additional lacquer mask prior to the isotropic undercutting, serve as an etching mask.--

1. An apparatus for measuring viscosity of a medium with a micromechanical measuring facility and electronic systems for measuring, transducing, and analyzing signals, with the following features:

a measuring zone [implemented] integrated on a mechanically stable substrate is freely accessible or enclosed within a measuring chamber with pores or openings for diffusive or convective mass transport, the measuring zone containing two or [several] more closely spaced conductors of which at least one is connected to a controllable current source or HF voltage source and of which at least one is completely or partially cantilevered [within] from a suspension into the measuring zone, the position of the cantilevered conductor(s) being defined within the measuring zone by the resiliency of the [bracket] suspension or their/its [own] inherent resiliency and by voltage-dependent, or current-dependent electrical or magnetic attraction, or repelling forces, which can be changed by [means of] said HF voltage [sources] source or current [sources] source, and the measuring zone containing an [implemented] integrated measuring [set up] device for [detection of the] detecting a viscosity-dependent change in position [change] of the conductor(s) in response to changes of said attraction or repelling forces.

2. The apparatus of claim 1, wherein the substrate [consists of] comprises a semiconductor material and contains [implemented] integrated circuits for detecting the position [respectively] or change in position [change] of the cantilevered [movable] conductor(s), and/or for the signal transduction, and/or the signal export, and/or for the controllable current or HF voltage sources.

3. The apparatus of claim 1, wherein [a tightly implemented] an integrated loop or flat coil and [a] the cantilevered [movable conductor] conductor(s) [forming a loop] are arranged on the substrate at the [place of] the measuring

zone, [this] the cantilevered [movable conductor] conductor(s) being [fixed to] suspended from the substrate at two or more points within the measuring zone.

4. The apparatus of claim 1, wherein the substrate is formed as a bar-shaped, thin tip at [the place of] the measuring zone.

5. The apparatus of claim 4, wherein the measuring zone is [connected with the outer medium] separated from the medium to be analyzed by a dialysis membrane[, the resulting] forming a measuring chamber [being] filled with a macromolecular sensitive fluid, the components of which cannot penetrate the dialysis membrane and the viscosity of which is determined by reversible affinity bonds between polymer substances and can be changed by the concentration of one or [several] more analyte molecules for which the dialysis membrane is permeable, wherein [at any point] the maximum spacing between the sensitive fluid volume [being bordered] confined by the dialysis membrane and the substrate is [not remote from the dialysis membrane by more than] .5 mm.

6. The apparatus of claim 5, wherein the bar-shaped, thin tip with the measuring zone is [arranged] positioned in and partially fills the lumen of a dialysis hollow fiber[, but not completely filling out this lumen, so that] for forming a measuring chamber the region between hollow fiber membrane and substrate [acts as a measuring chamber].

7. The apparatus of claim 6, wherein the [movable] cantilevered conductor(s) [which is/are [(are)] cantilevered in the measuring zone] consist(s) of thin metal wires and wherein the resilient resistance of the [movable] conductor(s) against the field-induced force is mainly based on the torsion of said wires.

8. The apparatus of claim 7, wherein the cantilevered [movable]

conductor(s) is/are arranged in the field of a permanent magnet [in] such [a way,] that [this] the field is directed perpendicularly relative to the [movable] conductor(s) and to their/its main direction of movement and wherein the [movable conductors] conductor(s) is/are connected to a controllable current source.

9. A method of measuring viscosity with a device according to claim 8, wherein the [position] change in the position of the cantilevered [movable] conductor(s) [referring] relative to the substrate or [one other] another conductor [being] is induced by a change of the electrical HF field or of the magnetic field intensity and the viscosity dependent velocity or extent of [this] the change in position [change being established] induced by [means of] a preferably high frequency capacity or impedance measurement or by [means of the] a frequency-shift of an HF-oscillator.

10. The method of measuring viscosity of claim 9, wherein the viscosity-dependent amplitude of the measured [position] change in position of the cantilevered [movable] conductor(s) is evaluated at a suitable modulation or switching frequency of the HF field affecting the [conductors] conductor(s) or of the current flowing in the conductor(s) or as function of the modulation or switching frequency.

11. The method of measuring viscosity of claim 9, wherein the [intensity] strength or direction of the magnetic force or the [intensity] strength of the electrostatic force [to] acting on the cantilevered [movable] conductor(s) is/are abruptly changed by the control of the current- or HF voltage [source(s)] source, and subsequently, the viscosity-dependent [position] change in position of the [conductors] conductor(s) is/are measured as a function of time.

12. A method of making a device for measuring viscosity according to [claims] claim 8, wherein after completion of all active and passive components of the viscosity [sensor] measuring device on a suitable semiconductor substrate (including the [implemented leading paths] integrated conductors), [but before separation of the chips jointly generated on the semiconductor substrate (wafer),] an additional photolithographically structured soft mask is applied [to enable] for a localized [isotrope insulator] isotropic insulation etching process on the parts of the [upper conducting path] uppermost conductor layer [being provided in the completed sensor as] for forming the cantilevered [movable] conductors and wherein [these] the parts of the [upper conducting path] uppermost conductor layer are undercut by etching and completely separated from [the] corresponding sections of [the] an insulating base [in] by the localized [isotrope insulator] isotropic insulation etching process.

13. The method of claim 12, wherein [the intermediate] a layer [between] intermediate the uppermost conductor [path] layer and [the] a lower conductor is dielectric and consists of at least two layers of different chemical compounds, and wherein the lower part of the [interlayer] intermediate layer is [not affected by] immune from the etching [agent used] process for the isotropic undercutting of the upper conductor path.

14. The method of claim 13, wherein the upper [partial] part of the intermediate layer [of the intermediate layer] consists of silicon dioxide or silicate glass and one of the lower partial layers consists of Si_3N_4.

15. An apparatus for measuring the viscosity of a fluid, comprising:

a substantially rigid support;

an extension protruding from the support and provided with a first conductive path;

a cantilever member comprising a second conductive path extending over the first conductive path and resiliently biased to a first position spaced therefrom;

means for cyclically energizing at least one of the first and second conductive paths for moving the cantilever member to a second position; <u>and</u>

means for detecting the rate of return of the cantilever member to its first position to derive a value representative of the viscosity.

16. The apparatus of claim 15, wherein the length and width of the extension are about 1 mm and 300 μm, respectively.

17. The apparatus of claim 16, wherein the extension and the cantilever member are mounted in a chamber formed by a membrane of predetermined permeability.

18. The apparatus of claim 17, wherein the membrane is a dialysis membrane and wherein the layout of the chamber is such that the distance between any point in the chamber and a permeable portion of the membrane does not exceed .3 mm.

19. The apparatus of claim 18, wherein the dialysis membrane has a molecular weight cut-off of about 10 kDa.

20. The apparatus of claim 19, wherein the chamber contains lyophized components of a fluid sensitive to glucose.

21. The apparatus of claim 15, wherein the at least one of [the] first and second conductive paths is adapted to be energized by direct current.

22. The apparatus of claim 15, wherein the at least one of [the] first and second conductive paths is adapted to be energized by high frequency voltage.

23. The apparatus of claim 22, wherein the high frequency voltage is in the Ghz range.

24. A method of measuring the viscosity of a fluid, comprising the steps of:

providing a substantially rigid member with a first conductive path therein;

providing a resiliently flexible member having a second conductive path therein biased into a first position spaced from the first conductive path;

subjecting the rigid and flexible members to the fluid;

energizing at least one of the first and second conductive paths to move the flexible member to a second position; and

measuring the rate of movement of the flexible member to derive therefrom a value representative of the viscosity.

25. The method of claim 24, wherein [the] at least one conductive path is energized by high frequency voltage and wherein the rate of movement is measured by the capacitance between the first and second conductive paths.

26. The method of claim 24, wherein [the] at least one conductive path is energized by direct current and wherein the rate of movement is measured by rate of relaxation of the resilient member.

27. The method of claim 24, wherein the rigid and resiliently flexible members are disposed in a measuring chamber formed by a membrane of predetermined permeability and wherein the chamber further contains a fluid sensitive to the fluid for measuring the viscosity thereof by affinity.

28. A method of fabricating an apparatus for measuring the viscosity of a fluid, comprising an elongate rigid member extending from a substrate of a semiconductor material for supporting a first conductive path and a second member supporting a second conductive path and mounted for oscillations relative to the first member, wherein the second member is formed by depositing on the parts of the substrate provided with the second conductive path an additional photolithographic lacquer mask for undercutting by localized isotropic insulator etching.

29. The method of claim 28, wherein an intermediate layer comprising at least two superposed layers of different chemical compounds is provided between the first and second conductive paths and wherein the etching step is performed on an upper one of the layers.

30. The method of claim 29, wherein the etching step is performed with an etching agent removing layers of one of silicon dioxide and silicate glass and immune to lower layers of Si_3Ni_4.